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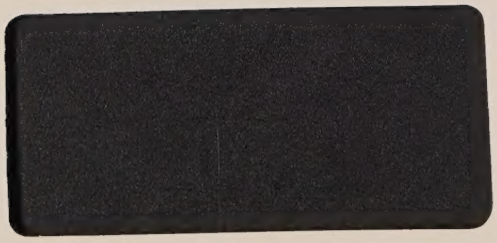
OPERATION
AND
SERVICE MANUAL

MODEL VR-2M
T.O.S. No. 126C
SERIAL NO.
PLUG-IN OSCILLATOR

Telonic® INSTRUMENTS

Division of Telonic Industries, Inc.



WARRANTY

TELONIC INSTRUMENTS AND ACCESSORIES

Products manufactured by TELONIC INSTRUMENTS; Division of Telonic Industries, Inc. are guaranteed against defective materials and workmanship for a period of one year (vacuum tubes excepted) from date of purchase. This warranty does not apply to instruments that have been altered, improperly handled or damaged in any way beyond our control.

Instruments must be examined immediately upon receipt, since claims for damage in transit will not be honored by the carrier unless prompt action is taken.

CHANGES IN SPECIFICATIONS

The right is reserved to change the published specifications of equipment at any time, and to furnish merchandise in accordance with current specifications, without incurring any liability to modify equipment previously sold.

RETURNING EQUIPMENT TO FACTORY

Factory service is available for repair and readjustment of this instrument. However, a description of the trouble, plus the MODEL AND SERIAL NUMBERS of the unit MUST be forwarded FIRST, whereupon instructions for correcting the trouble OR authorization for returning the equipment will be given. This applies to all units, whether under warranty or not. Contact TELONIC INSTRUMENTS at Post Office Box 87, Beech Grove, Indiana 46107 or your local TELONIC representative.

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CONVERSION INFORMATION

Commencing with equipment shipped after about July 22, 1963, certain modifications have been incorporated in the Telonic SM-2000 plug-in series, and in the Telonic SM-2000 control chassis. These modifications may render the units incompatible with those previously shipped unless the earlier instruments are modified also. The equipment in which these modifications have been made can be identified by the letter "A" prefixed to the serial number.

Units not so identified must be modified if they are to be compatible with instruments now being shipped. The modifications to be made are listed below, divided into two groups - those to be made to earlier SM-2000's and those to be made to earlier plug-ins.

SM-2000 CHANGES

1. On J601, remove all wires presently connected to pin 8 and reconnect them at pin 7; remove the jumper between pins 7 and 8.

2. Using shielded wire, type RG-174/U or equal, connect pin 8 of J601 to the printed circuit board land which leads to pin 1, V303. Ground the shield by connecting it to a convenient ground land nearby.

3. Prefix the letter "A" to the serial number of the instrument.

PLUG-IN CHANGES

1. On P601 remove all wires presently connected to Pin 8 and reconnect them at pin 7; remove the jumper between pins 7 and 8 if one is connected.

2. Prefix the letter "A" to the serial number of the instrument, if none is prefixed.

Changing the serial number of the instrument is as important in the modification as are the electrical requirements, as the ability to identify a unit as having been or not having been modified is involved.

SECTION I .. SPECIFICATIONS

MODEL VR-2M

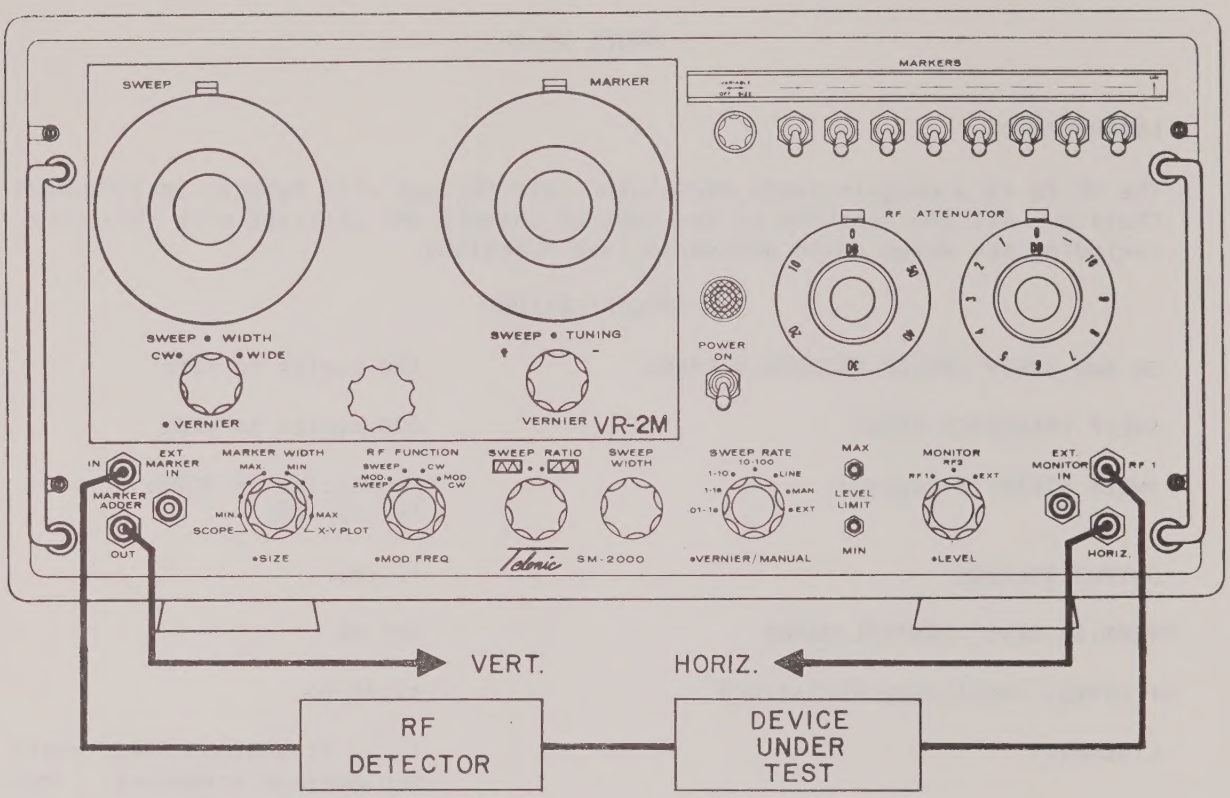
INTRODUCTION

The VR-2M is a plug-in sweep oscillator unit for use with Telonic SM-2000 Control Chassis. All the features of the control chassis are utilized with this unit, including the sweep ratio and sweep rate functions.

SPECIFICATIONS

CW AND SWEEP CENTER FREQUENCY RANGE	200 cycles to 12Mc
SWEEP FREQUENCY RANGE	200 cycles to 12Mc
SWEEP WIDTH (2 Ranges)	100 cycles to 400kc 1kc to 10Mc
OUTPUT VOLTAGE	1v rms
*VERNIER LEVEL CONTROL RANGE	0-6 db
*FLATNESS (Amplitude Variation)	±0.25 db
LINEARITY	1:1.2 at maximum sweep width and maximum frequency. Improves with decreasing sweep width and frequency.
RESIDUAL POWER SUPPLY HUM	Less than 50 cycles at minimum sweep width
STABILITY (After Warmup)	
Short Term (1 minute)	1kc
Long Term (1 hour)	10kc
VARIABLE MARKER	
Frequency Range	0 to 12Mc
Accuracy	± 150kc
Calibration Marks	Every 200kc
Birdy Marker Width	Adj. 5 to 50kc

*The level control range and flatness specifications apply over the 250kc-12Mc frequency range only. When operating below 250kc, the automatic level control circuitry must be disabled by setting the control chassis MONITOR switch in the RF 2 position. The output level can then be controlled in 1 db steps with the turret attenuators. Flatness over the 200 c.p.s.-250kc range is ±0.25db.



DESCRIPTION OF FRONT PANEL

SWEEP — Tunes the center frequency over 200 cps-12 Mc range.

MARKER — Tunes the variable marker over the 0-12 Mc range.

SWEEP WIDTH

Coarse (switch) — Selects CW or SWEEP mode of operation and wide or narrow sweep width.

Vernier — Varies sweep width within each range. Has no effect when coarse control is in CW position.

GENERAL

1. Make sure the control chassis power is OFF before plugging in the VR-2M. If the power is on, transient voltages may cause damage.
2. Make connections to the scope (or recorder), the device under test, and r-f detector as shown. All connectors located on the sweep generator are BNC type and it is recommended that RG cable be used for all connections. This insures good ground connection between the devices, minimizes hum, and reduces leakage from the unit and pickup of spurious external signals. The cable that is used to connect the RF OUTPUT to the device under test should match the impedance of the sweep generator, or else a matching network should be used to insure a constant input signal. Turn on the power.

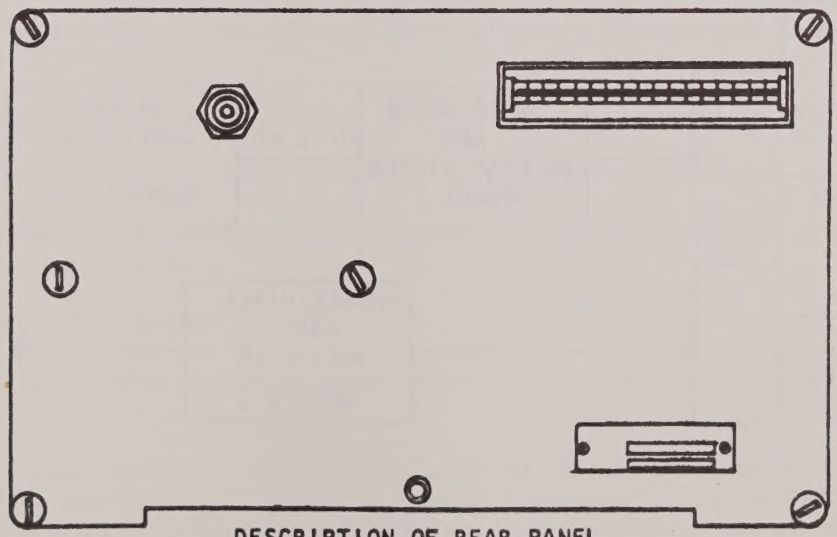
3. The SWEEP WIDTH control on the control chassis is not operative with the VR-2M. Sweep Width is determined by the setting of the VR-2M SWEEP WIDTH controls. For proper operation, the FUNCTION switch on the control chassis must be set for the same mode of operation as the coarse SWEEP WIDTH control on the VR-2M.

4. For proper operation of the VR-2M, set the control chassis MONITOR Switch to the RF 1 position, the LEVEL Control fully clockwise, and set the output at 1v r.m.s. with the MAX LEVEL LIMIT Control; then, with LEVEL fully counter-clockwise, set the output 6 db below 1v r.m.s. with the MIN LEVEL Control. A procedure for accomplishing this setting is outlined in Section II of the control chassis manual.

5. Refer to Section II of the control chassis manual for additional instructions. The function of each front panel control is discussed there, except as modified by paragraph 3 above for this particular plug-in.

6. If operation is not normal, refer to Section IV of this manual and of the control chassis manual. It is particularly important that the supply voltages and the sweep drive waveform be adjusted to the values prescribed in the control chassis manual, using the most accurate standards available.

DRAWING OF REAR PANEL



DESCRIPTION OF REAR PANEL

The two electrical connectors on the rear panel are:

A BNC plug, which mates with a BNC jack on the control chassis. This is the RF output connector.

A 32-contact plug which makes the other electrical contacts necessary through a mating socket on the control chassis.

SECTION III .. GENERAL DESCRIPTION

GENERAL

The VR-2M is a heterodyne-type plug-in in which the output of a tunable swept oscillator is combined with that of a crystal-controlled fixed oscillator in a balanced mixer. The difference frequency is then amplified and brought out as the r-f output signal.

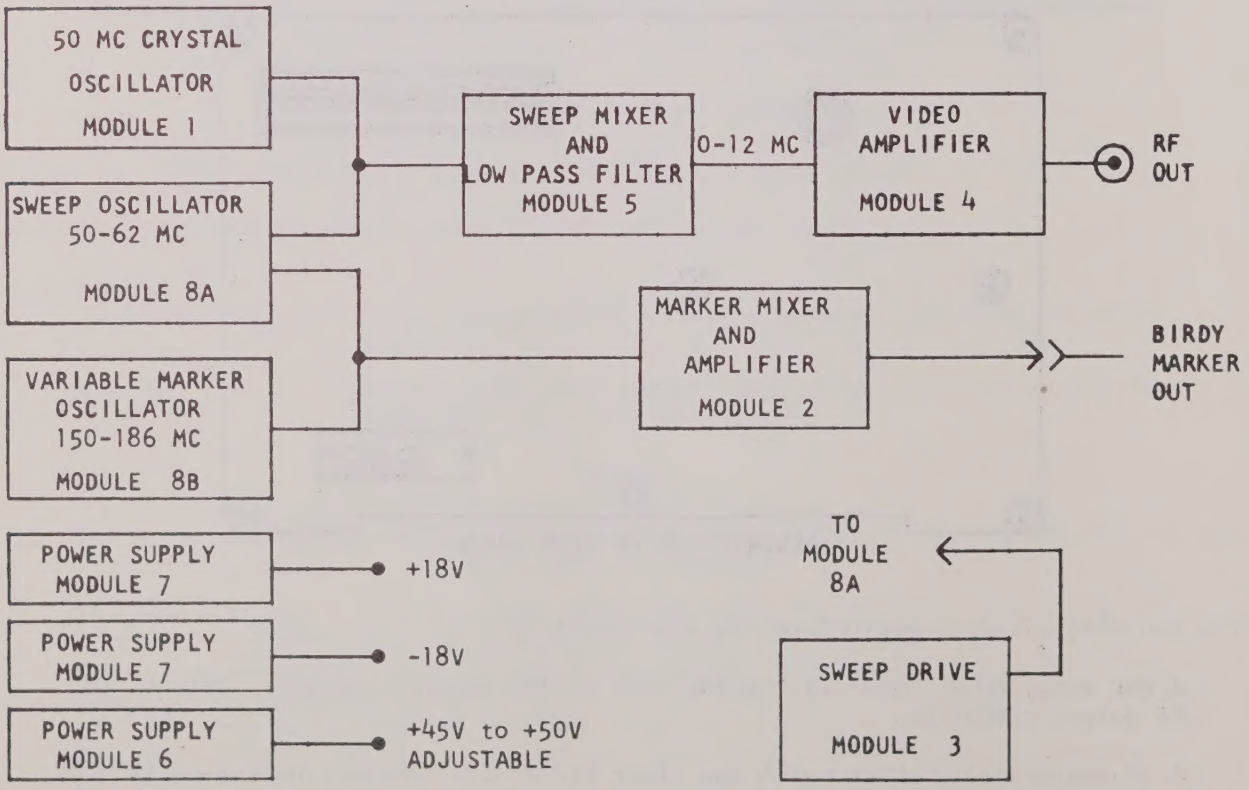
Approximately 90% of this unit consists of plug-in or easily removable modules. The Circuit is completely transistorized except for module No. 3, which utilizes Nuvistor triodes. Since the control chassis is primarily a vacuum-tube unit, the VR-2M contains two power supplies, one furnishing +18v and the other -18v. These voltages are generated from the 12.6v winding on the control chassis power transformer.

The VR-2M also contains a variable oscillator which produces a marker over the entire swept range.

MODULAR CONSTRUCTION

The unit basically consists of 8 basic module types plus a few chassis-mounted components.

SIMPLIFIED BLOCK DIAGRAM


50 MC CRYSTAL OSCILLATOR MODULE 1
SWEEP OSCILLATOR 50-62 MC MODULE 8A
VARIABLE MARKER OSCILLATOR 150-186 MC MODULE 8B
SWEEP MIXER AND LOW PASS FILTER MODULE 5
0-12 MC
VIDEO AMPLIFIER MODULE 4
RF OUT
MARKER MIXER AND AMPLIFIER MODULE 2
BIRDY MARKER OUT
POWER SUPPLY MODULE 7
+18V
POWER SUPPLY MODULE 7
-18V
POWER SUPPLY MODULE 6
+45V to +50V ADJUSTABLE
TO MODULE 8A
SWEEP DRIVE MODULE 3

MODULE 3 - SWEEP-DRIVE SHAPING

The input to this circuit is the +20v to +120v output of the control chassis "Vari-rate" sweep-drive circuit. The input waveform has a nearly constant slope during the time the sweep oscillator is on. At wide sweep widths, the frequency will not be a linear function of time using this waveform because of the varactor diode characteristics. This circuit is designed to compensate for this non-linear relationship.

The circuit has two outputs. One of these is simply the input waveform, shifted in d-c level by a series zener diode, as passed by a cathode follower. The other is shaped by a varistor-resistor combination to a peaked wave form with concave slopes, so that the slope is much sharper at the peak than at the base. This shaping is accompanied by a loss of amplitude which is restored by a negative feedback amplifier.

These two outputs are applied at opposite ends of one section of the SWEEP WIDTH control. When the SWEEP WIDTH switch is set to CW or the narrow sweep width range, and when the SWEEP WIDTH Vernier is fully counter-clockwise in the wide sweep width range, the sweep-drive wave form has the constant slope. At maximum sweep widths it is of the peaked shape described in the preceding paragraph.

At intermediate sweep width settings, the sweep drive will have some of the characteristics of each of these waveforms, tending more to constant slope at low sweep width and more to concavity at high sweep widths.

This module contains four controls:

CENTERING MIN SWEEP, which adjusts the average (d-c) level of the constant-slope waveform.

CENTERING MAX SWEEP, which adjusts the average (d-c) level of the concave wave-form.

LINEARITY, which adjusts the slope of the concave waveform.

AMPLITUDE, which adjusts the amplitude of the concave waveform and thus determines the maximum sweep width.

MODULE 8A - SWEEP OSCILLATOR CIRCUIT

The sweep oscillator is a common-emitter Colpitts circuit operating over the 50-62 Mc range.

The sweep-drive wave form from module 3 is applied through the SWEEP WIDTH control to a varactor diode in the tank circuit. The center frequency is varied with a non-contacting variable inductance, providing infinite resolution with no contact noise.

The collector supply to the sweep oscillator is an extremely stable voltage, adjustable between +45v and +50v, from module 6.

The sweep oscillator output is amplified in two buffer stages and fed to module 5 for mixing with the crystal oscillator output from module 1.

The collector supply for the buffer stages is the blanked, leveled B+ voltage from the control chassis. This voltage is lowered to the operating range of the transistorized circuit by a series zener diode and limited to a maximum of +18v by a diode which becomes forward-biased when the voltage tends to rise above this value.

A low-power sample ("sweep sample") of the output is fed to module 2 for mixing with the marker oscillator signal.

MODULE 1 - 50 MC CRYSTAL OSCILLATOR

This module contains a crystal-controlled Colpitts oscillator operating at 50 Mc link-coupled to a buffer stage. The buffer signal is link-coupled to and applied across the OUTPUT ADJ control, which determines the amplitude of the c-w output from this module.

The output is heterodyned in module 5 with the signal from module 8A.

The collector supply for both stages is the +18v from the power supply.

MODULE 5 - SWEEP MIXER

This module performs three circuit functions:

1. A buffer stage is included for each of the r-f inputs. One input is the swept output of module 8A and the other is the crystal-controlled c-w output of module 1. The SWEEP INPUT ADJ determines the amplitude of the swept signal at the buffer input.

2. These two r-f signals are heterodyned in a balanced mixer.

3. The heterodyned signals are coupled to the output through a low-pass filter which cuts off at about 12 Mc, rejecting fundamental and sum frequencies.

The supply voltage for the buffer stage is the blanked, leveled voltage described in the discussion of module 8A.

MODULE 4 - VIDEO AMPLIFIER

The heterodyne difference frequency from module 5 is fed to this module for further amplification in a d-c coupled wide-band circuit. Negative feedback is provided for stability. The output of this circuit is the r-f output of the VR-2M.

This circuit uses both the +18v and -18v supply voltages.

A BALANCE adjustment is provided to eliminate d-c content in the output and a GAIN adjustment to determine the amplitude of the negative feedback.

MODULE 8B - VARIABLE MARKER

The marker oscillator is a push-pull Colpitts circuit tunable from 150 Mc to 186 Mc. The inductive tuning used is similar to that described for the sweep oscillator. The oscillator is isolated from the output by a buffer stage.

The collector supply is derived from the switched +100v supply in the control chassis. A dropping resistor and a diode with the cathode returned to +18v limit the voltage supply to the module to that value.

The output is coupled to module 2 and heterodyned with the sweep sample.

MODULE 2 - MARKER MIXER

The sweep sample and marker buffer output are coupled to a two-diode mixer circuit, which also is an effective harmonic generator. The third harmonic of the sweep sample heterodynes with the signal from the marker unit to produce a zero beat, or "birdy." The birdy width is one third that of the birdy which would be produced by heterodyning two signals in the same frequency range.

The birdy is shaped by a pi-section low-pass LC filter, amplified in one stage, and fed to the birdy-by-pass system in the control chassis.

This module includes a marker size control preceding the amplifier stage. This is used to adjust the amplitude of the variable marker.

The collector supply is the +18v from the VR-2M power supply.

MODULE 7 - +18v and -18v POWER SUPPLIES

Two identical two-terminal power supplies furnish the low voltages required for the transistorized circuitry. These supplies operate on a principle similar to that of module 6, the principal difference being that there is no internal reference and the circuitry is such that either terminal may be grounded. Grounding one of the terminals gives a nominal output of +18v; grounding the other provides -18v.

Close-tolerance components maintain the output within ±0.25v of the nominal values.

There are no adjustments on these supplies.

MODULE 6 - +45-50v POWER SUPPLY

This module furnishes a well-regulated d-c voltage, adjustable over a 45-50v range.

The input to the circuit is +175v from the control chassis. This voltage is divided to furnish the output voltage. The electronic regulation is provided by amplifying any "error," or deviation, in the output voltage, and applying a correcting signal to counteract the error.

The output impedance of this circuit is a small fraction of that of a zener diode. This circuit has a grounded reference and is irreversible; i.e., it cannot be used as a negative supply by reversing the output connections.

An adjustment is provided on the module to set the output voltage at the desired level.

OTHER COMPONENTS

The balance of the parts are chassis- and front panel-mounted and consist of the power transformer, two full-wave rectifiers, the SWEEP WIDTH coarse and vernier controls, and several voltage dropping resistors, filters, and diode clamps.

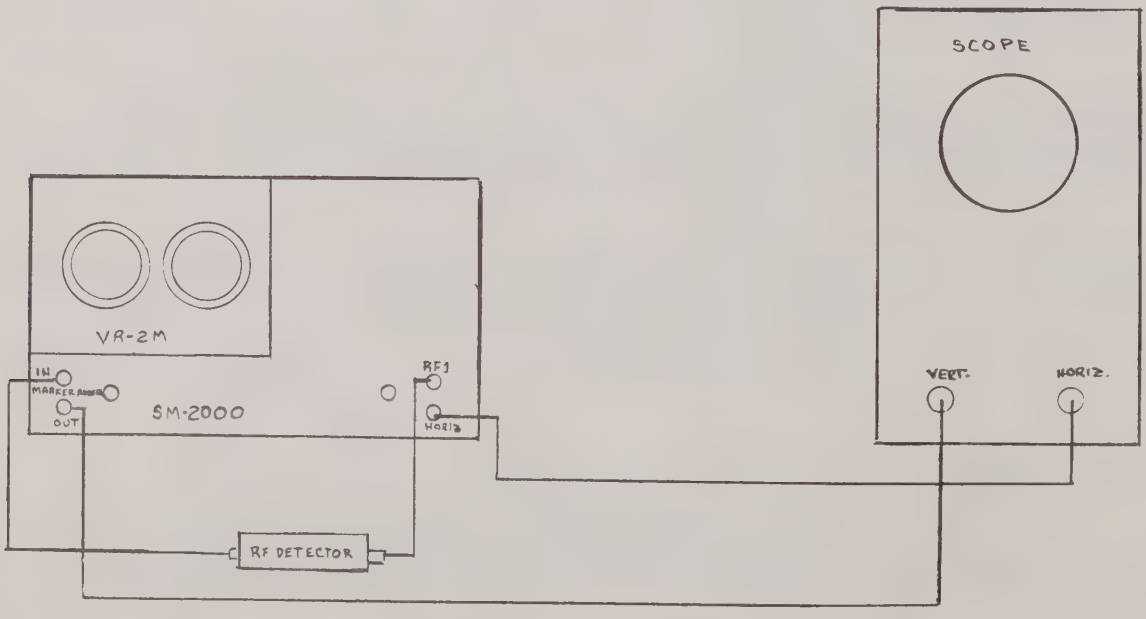
SECTION IV - CERTIFICATION PROCEDURE

TEST EQUIPMENT REQUIRED

High-frequency d-c oscilloscope
R-f detector, such as the Telonic Model XD-6A or XD-3A*
Amphenol connector adaptor 27-29*
1-Mc harmonic marker unit such as the Telonic Model CDH-1.0
0.1-Mc harmonic marker unit such as the Telonic Model CDH-0.1
20kΩ/v voltmeter or vacuum-tube voltmeter
Milliammeter

*It is recommended that the detector have a 50Ω input impedance, about 75% efficiency, and a low cutoff frequency. Although the test procedure was written using the Telonic Model XD-6A, other detectors of similar characteristics can be expected to give comparable results. The diode used in the models named is the 1N416B.

TEST SETUP



TEST PROCEDURE

General. A simple method for certifying the performance of the VR-2M is checking it against the following check-off list, prepared from the SPECIFICATIONS listed on page 1, plus a few additional items. It is suggested that this sheet be reproduced for use in conducting this check at intervals of ninety days or less. Test procedures are provided, beginning on the next page, for those tests in which the method may not be obvious.

CHECK	ITEM	SPECIFICATION
	CW AND SWEEP CENTER FREQUENCY RANGE	200 c.p.s.-12Mc
	SWEEP WIDTH (narrow range)	100 c.p.s.-400kc
	SWEEP WIDTH (wide range)	1kc-10Mc
	CENTER FREQUENCY VARIATION (over full range of SWEEP WIDTH vernier)	Not over 2%
	OUTPUT VOLTAGE	1v r.m.s.
	D-C CONTENT IN OUTPUT	Not over 10mv
	VERNIER LEVEL CONTROL RANGE	0-6db
	FLATNESS	0.5db
	LINEARITY (at full sweep width and maximum frequency)	1.2:1
	RESIDUAL POWER SUPPLY HUM (at minimum sweep width)	Less than 50 c.p.s.
	SHORT TERM FREQUENCY STABILITY (1 min.)	1kc
	LONG TERM FREQUENCY STABILITY (1 hr.)	10kc
	VARIABLE MARKER FREQUENCY	0-12Mc
	VARIABLE MARKER ACCURACY	±150kc
	VARIABLE MARKER AMPLITUDE (at MARKER ADDER OUT connector with full sweep width at 5Mc)	5v peak-to-peak
	MINIMUM LEVELED FREQUENCY	250kc

CERTIFICATION PROCEDURE

The following paragraphs detail the specific procedure to be used in checking certain items listed on the preceding page. If the unit fails to perform as specified in one or more respects, refer to Section V of this manual for the adjustment procedure and other trouble-shooting information. A warmup period of at least one hour must be provided before the results of this procedure are completely reliable.

CW and Sweep Center Frequency range. Connect the equipment as shown in the TEST SETUP. The RF side of the detector is connected to RF 1, the dc side of the detector is connected to MARKER ADDER IN. Connect a cable from MARKER ADDER OUT to the vertical input of the scope. Connect a cable from HORIZ. to the horizontal input of the scope. Set the oscilloscope controls for an externally supplied horizontal voltage and a trace 10 cm. long. Set the vertical scale at about 0.2v/cm.

Set the control chassis in the SWEEP mode, the VR-2M SWEEP WIDTH to narrow with the vernier fully clockwise. Turn on the 1-Mc harmonic markers. Set the SWEEP dial to 1 Mc and locate the 1-Mc marker. Rotate the dial to the high-frequency stop, counting the markers. The high-frequency end of the sweep must be at least 12Mc.

Set the MONITOR switch to RF 2 and the FUNCTION switch and coarse VR-2M SWEEP WIDTH control to CW. Set the oscilloscope for an internally generated trace 10 cm. long with a time base of 1 millisecond/cm. Omit the detector from the setup so that the r-f output is displayed directly on the oscilloscope. Carefully set the SWEEP dial near zero so that two cycles appear on the trace. The waveform should be essentially sinusoidal at this frequency (200 c.p.s.). At this low frequency the power supply hum will be evident but not sufficient to obscure the shape of the waveform. This verifies the low end of the frequency range.

Residual power supply hum. Set the FUNCTION switch to CW and the VR-2M SWEEP WIDTH control to narrow with the vernier fully counter-clockwise. Set the MONITOR switch to RF 2. With other controls set as at the conclusion of the frequency range check, carefully set the SWEEP dial to 1kc (ten cycles on the oscilloscope). Measure the "vibration" of the end of the tenth cycle. A Vibration of 0.5 cm. represents a residual hum of 50 c.p.s.

The hum may be measured at other frequencies within the bandpass of the oscilloscope, and with other time bases, but will be essentially the same throughout the frequency range.

Drift. The drift can be read using a counter if available, or the method described here may be used instead. Leave controls not mentioned set as at the conclusion of the hum check. Insert 30 db of attenuation with the turret attenuator and turn on the 1-Mc marker. Set the MARKER WIDTH control to SCOPE MIN and switch to the CW mode.

Carefully set the SWEEP dial at a harmonic of 1Mc. Drift will be essentially constant over the frequency range. Adjust the dial so that a 1-kc "beat" (ten cycles) appears on the 10-cm. trace, then time the period over which the drift is to be measured (one minute). The change in the number of cycles during the one-minute period indicates the drift. For instance if only a small portion of a cycle remains on the oscilloscope, or if the number of cycles has doubled (to twenty), the drift is approximately 1kc.

In this and other measurements involving beat-frequency measurements, it may be convenient to set the center frequency with the vernier after an approximate setting with the dial.

The long-term drift can be measured with sufficient accuracy in the SWEEP mode, using 0.1-Mc markers. Switch to the SWEEP mode and turn on the 0.1-Mc marker. Remove the 30 db attenuation and set the oscilloscope controls for an externally supplied horizontal voltage. Set the SWEEP WIDTH so that one marker interval occupies 10 cm. on the trace. Position a marker on a graticule line and start the one-hour timing. A one-centimeter change in the position of the marker represents a drift of 10kc.

Sweep width. The minimum sweep width on both ranges is measured using a "beat" similar to that used in measuring drift.

Again switch in 30db of attenuation and set the oscilloscope controls for an internally generated 10-cm horizontal trace with a time base of 1 millisecond/cm. Set the SWEEP dial at 5Mc and turn on the 1-Mc harmonic marker. Turn off the 0.1-Mc marker. Set the SWEEP WIDTH control to the WIDE position and the vernier fully counter-clockwise. Set the control chassis SWEEP RATE switch to MANUAL. Turn the MANUAL/VERNIER knob on the control fully clockwise and set the SWEEP dial for ten cycles on the oscilloscope. Rotate the MANUAL/VERNIER knob fully counter-clockwise and count the number of cycles remaining on the oscilloscope. Each cycle change represents 100 c.p.s. of sweep width; thus if six cycles remain the minimum sweep width in the WIDE position is 400 c.p.s. Repeat the procedure in the narrow position of the SWEEP WIDTH control.

The maximum sweep width is measured on each sweep width range with the SWEEP WIDTH vernier fully clockwise by counting 0.1-Mc and 1-Mc marker intervals. Remove the 30db attenuation and set the oscilloscope controls for an externally supplied horizontal deflection voltage. Turn on the 0.1-Mc harmonic marker for the narrow range or the 1-Mc marker for the wide range and count the intervals. If the "zero" marker is on the oscilloscope, use the SWEEP dial to position it as far to the left as possible and count the intervals to the right of it. In the narrow range, it should be moved off the trace.

R-f output. The r-f output can be measured using a high-frequency oscilloscope if one is available.

This measurement also can be made using an r-f detector as shown in the TEST SETUP. For best accuracy, it is preferable that the detector be calibrated against an r-f power meter at 20Mc. The Telonic Model XD-3A is sufficiently frequency-insensitive for this calibration to be accepted above 100kc in the VR-2M range.

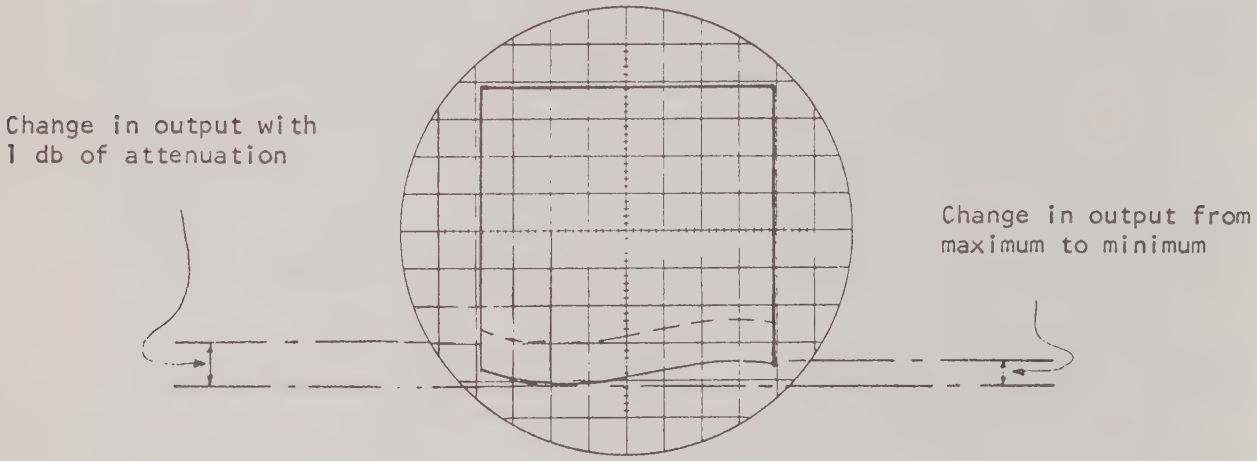
If it is inconvenient to calibrate the detector against a power meter, it is best to estimate the r-f output as 1v r.m.s. when the vertical amplitude of the oscilloscope pattern is about 1.2v.

Rotate the LEVEL control fully clockwise, leaving other controls set as at the conclusion of the sweep width measurement. Adjust the vertical gain for 0.2v/cm. and measure the detected output across the entire band.

Flatness. Leave controls set as above and set the SWEEP WIDTH control for maximum sweep width. Tune across the band to locate the maximum and minimum outputs. Insert 1db of attenuation with the front-panel attenuator. See figure on the next page. Over a 1db range of attenuation the actual flatness can be measured with sufficient accuracy by comparing the difference between maximum

and minimum ("unflatness") with the reduction caused by 1db attenuation. For instance, if the unflatness is one-fifth of the reduction caused by 1db attenuation, the flatness is said to be 0.2db (or ±0.1db).

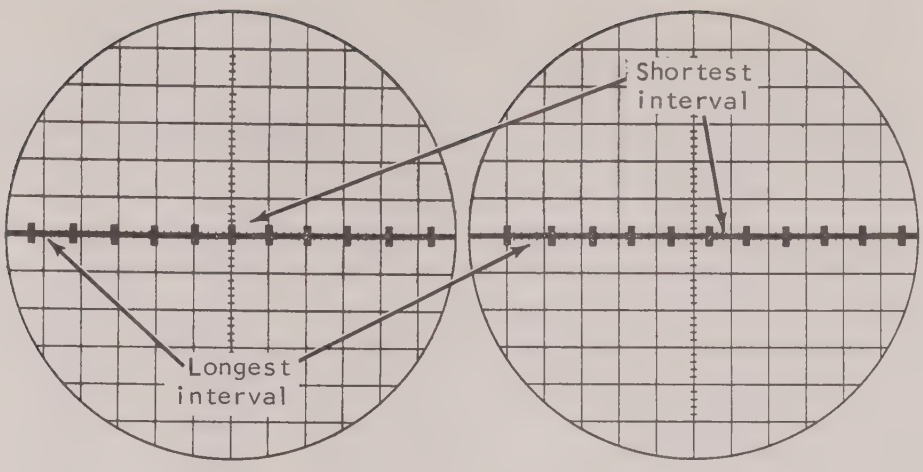
This measures the flatness of the negative signal peaks. The true flatness test requires that the unflatness of the positive peaks be included in the computation. This can be read with the diode reversed in the detector, or both envelopes can be evaluated using a device like the Telonic Model XD-6A, which contains two XD-3A's, one with a reversed diode. The total unflatness is half the sum of the reading for the two envelopes.



The flatness from 200 c.p.s. to 250kc is measured separately with the MONITOR switch in the RF 2 position. Since this frequency range probably extends well below that of the detector, this flatness is best measured by displaying the r-f output on the oscilloscope. Again, the unflatness is half the sum of the readings for the two envelopes.

Level control range. Return the controls to the same position as at the conclusion of the output level check and insert 6 db of attenuation. Note the level of the detected r-f output on the oscilloscope. Remove the attenuation and rotate the LEVEL control fully counter-clockwise. Using the MIN LEVEL LIMIT control set the same r-f output that was noted with the 6db of attenuation. The detected trace still should be "leveled" - that is, any adjustment of the LEVEL or MIN LEVEL LIMIT control should move the entire detected envelope (but not the zero base line), and the unflatness of the envelope should be no worse than that measured in the preceding test.

Linearity. Return the LEVEL control fully clockwise and leave other controls set as at the conclusion of the previous test. Turn on the 1-Mc harmonic marker. Rotate the SWEEP dial through a sufficient range to observe all markers in the 0-12Mc range and locate the shortest marker interval. Adjust the oscilloscope horizontal gain so that the interval occupies exactly one centimeter. Locate the longest marker interval and measure the length in centimeters. This length indicates the linearity ratio; thus if the longest marker interval is 1.15 cm. long, the linearity ratio is 1.15:1. See figure on next page.

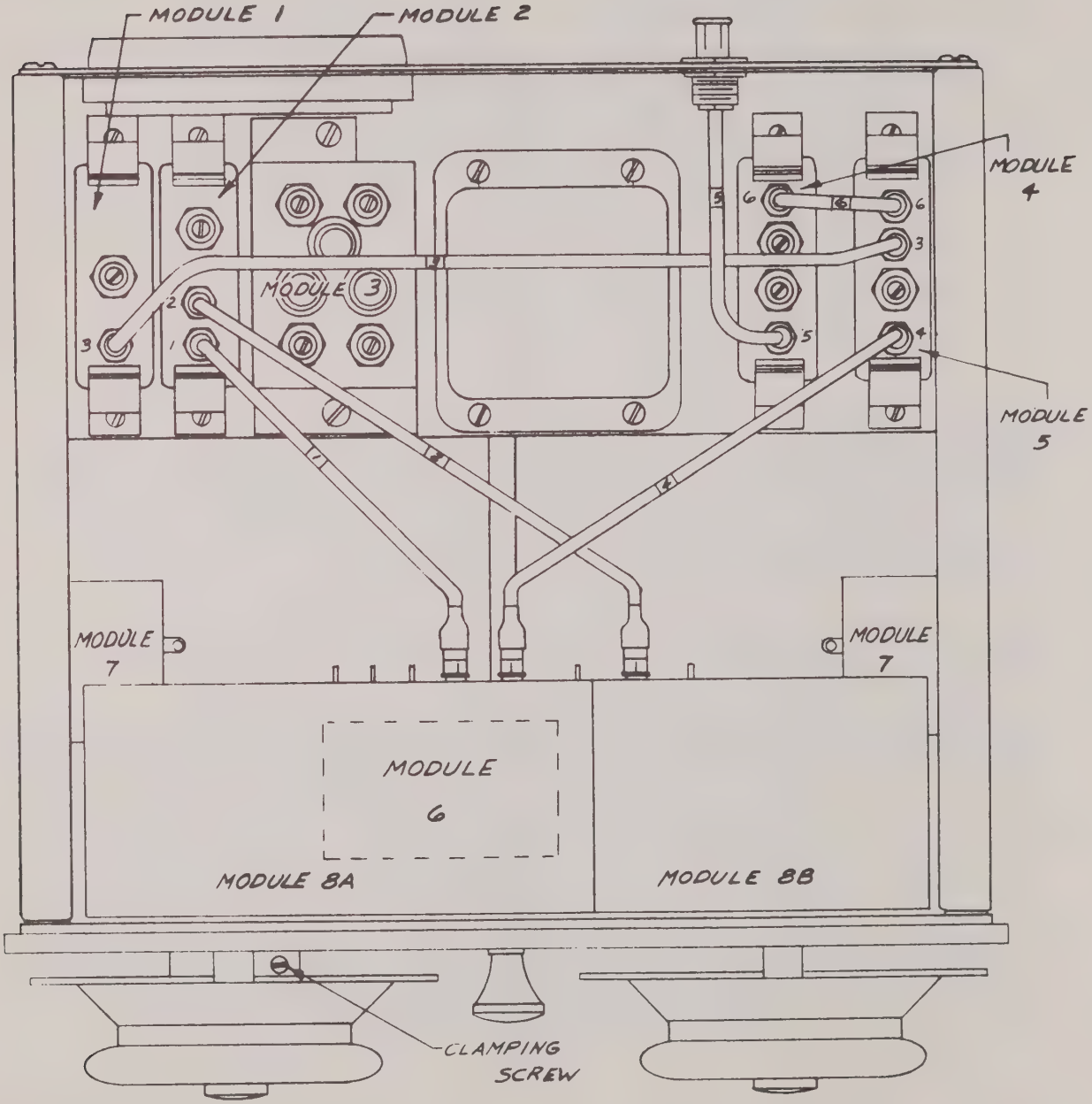


Variable marker dial accuracy. Set MARKER WIDTH to SCOPE MAX. Identify any particular 1-Mc harmonic marker. Lower the sweep width and adjust the SWEEP dial and vernier so that this marker occupies a considerable portion of the trace. Adjust the MARKER dial to position the variable marker in the center of the harmonic marker and read the MARKER dial. It should read within 150kc of the frequency indicated by the harmonic marker.

Variable marker amplitude. Set SWEEP WIDTH and MARKER SIZE to maximum. Set the center frequency at 5Mc. Measure the variable marker amplitude. It should be at least 5 volts peak-to-peak.

Center frequency variation over full range of SWEEP WIDTH vernier. Set MARKER WIDTH to SCOPE MAX. Adjust the horizontal gain of the oscilloscope for a 10-cm. trace. Set the SWEEP WIDTH control in the WIDE position. Center a 1-Mc harmonic marker on the presentation, using the SWEEP dial and center frequency vernier. Rotate the SWEEP WIDTH vernier throughout its range, noting the position of the centered marker. It should not shift from the center of the presentation by more than 2 mm. at any setting of the SWEEP WIDTH vernier.

D-c content in output. Adjust the vertical positioning controls on the oscilloscope so that the zero base line is in the center of the display. Disconnect the vertical input to the oscilloscope and observe the vertical shift in the zero base line. This displacement should not be over 10mv.



CHASSIS LAYOUT
Top View

The first step in the trouble-shooting procedure should be a check of the following trouble-shooting hints, with particular attention to the recommended adjustment procedure.

TROUBLE-SHOOTING HINTS

TROUBLE	POSSIBLE CAUSE AND/OR ADJUSTMENT PROCEDURE
SWEEP dial off frequency	Dial incorrectly indexed. Rotate dial counter-clockwise until the 10-Mc marker (tenth 1-Mc harmonic) is centered on the trace with SWEEP WIDTH adjusted so that the marker fills the trace. Loosen the screw holding the dial assembly on the shaft, but leave the assembly on the shaft. Rotate the mechanical vernier until the 10-Mc mark on the dial aligns with the indicator on the front panel. Tighten the screw on the assembly.
MARKER dial off frequency	Rotate the MARKER dial to center the variable marker "birdy" is centered in the 10-Mc marker. Loosen the screw holding the MARKER dial assembly in place and align the 10-Mc mark with the front panel indicator. Tighten the screw on the assembly.
SWEEP dial off frequency, or excessive frequency drift at low sweep width	Module 6 defective or maladjusted. The calibrating voltage is stamped on the lid to this module. The voltage may be set ±0.5v from this value if necessary to correct the trouble, but if greater misadjustment is required the module probably is defective and should be replaced.
SWEEP dial correctly calibrated, but center frequency shifts when SWEEP WIDTH is varied; display linearity poor; inadequate sweep width	Adjust Module 3 as follows: Use the setup shown in Section IV. Set the oscilloscope controls for an externally supplied horizontal signal and adjust the gain and position controls for a centered 10-cm. horizontal trace. Connect the detector from RF 1 to the vertical input on the oscilloscope and position the trace representing the detected r-f output near the center of the presentation. Turn on the 1-Mc harmonic marker. Set the VR-2M SWEEP WIDTH to WIDE and the vernier fully clockwise. Center the "zero birdy" marker on the oscilloscope pattern with the SWEEP dial. Set SWEEP WIDTH to the center (narrow) position, leaving the vernier fully clockwise. Again center the "zero birdy," using control D. Turn SWEEP WIDTH to WIDE, with the vernier still clockwise, and again center the "zero birdy," using control F. Now adjust controls C and E for just over 10-Mc sweep width with the best possible linearity, or evenness of marker spacing (See Section IV for linearity measurement). Since controls C, D, E, and F interact, these adjustments may have to be repeated several times in the same order as above. At the conclusion of these adjustments the "zero birdy" should remain centered as the SWEEP WIDTH vernier is varied from counter-clockwise to clockwise in the WIDE position of the control. Now center the 5-Mc marker with the SWEEP dial. Readjust controls in the above order until best possible linearity (1.2:1 or better) is obtained with 10-Mc sweep width and 5-Mc center frequency. If these adjust ments fail to correct the trouble, check SWEEP WIDTH coarse and vernier controls and associated wiring. If these are serviceable and correct, replace NUVISTOR tubes or entire Module 3 as necessary.
Low r-f output	No attempt to adjust any VR-2M controls should be made until a check of the detector, oscilloscope, attenuators, LEVEL controls, and associated cable connections is completed. With the SWEEP WIDTH control on the VR-2M and the FUNCTION switch on the control chassis in the CW position, an r-f power meter operating in this range can be used to check for 1v r.m.s. output. If trouble is not located by this method, a check on the r-f output of Modules 8A, 1, 5, and 4 can be made. Set the controls to the SWEEP mode and the MONITOR switch to RF 2. Apply the procedure specified later in this section for checking Modules 8A, 1, 5, and 4.
R-f output not at 0v d.c.	Adjust control G. Replace Module 4 if necessary.
Variable marker amplitude too high or too low	Adjuts control B. Replace Module 2 if necessary.

If the trouble cannot be rectified using the above procedures, then the trouble should be isolated to the control chassis or the VR-2M. This usually can be done simply by checking the voltage supplied to the VR-2M from the control chassis through P601. Preset the following controls:

SWEEP RATE to LINE
FUNCTION switch to SWEEP
SWEEP RATIO for 1:1
MONITOR to RF 1

Next check the following on P601:

PIN NUMBER	VOLTAGE OR WAVEFORM
5, 2, and 18	+100v, ±1v, approximately 2mv 60 c.p.s. ripple.
28	Triangular or sawtooth waveform with excursion from +20v to +120v.
12	-150v, ±5v, approximately 20mv 60 c.p.s. ripple.
13	-87v, ±5v, approximately 2mv 60 c.p.s. ripple.
9 to 7	6.3v a.c., 60 c.p.s.
9 to 6	12.6v a.c., 60 c.p.s.
4 and 24	175v, ±1v, approximately 5mv 60 c.p.s. ripple.
1	Same as pin 5 if front-panel VARIABLE MARKER switch is on.
31	Square wave with 0v at base and +25v to +105 volts at top. The amplitude should vary smoothly with the LEVEL control setting. Adjust the MAX and MIN LEVEL LIMIT controls to obtain this pattern. No r-f output with 105v amplitude at this pin indicates trouble in the VR-2M or the attenuators. If varying the LEVEL control causes a sudden change in the amplitude from 25v to 105v, or if the r-f output is over 1v r.m.s., the trouble probably is in the control chassis.

After isolating the trouble to the plug-in, the trouble can be isolated further to one of the eight modules. The following is a list of certain specifications for each module. If the output from a module is not as specified, first check the input (see schematics, Section VI) before replacing the module. Also, the outputs from Modules 7 (two modules used) and 6 could be low because of either an overload in another module or a defective Module 6 or 7. Modules 8B and 2 need be checked only if there seems to be trouble in the variable marker section.

Refer to the chassis layout for location of the modules.

Power Supplies

Module	Output	Ripple (peak-to-peak)	Probable cause of trouble
7	+18v	8mv at 200ma load	Check voltage at the output of the rectifiers. This should be +27v with about 2v (peak-to-peak) ripple. Remedy: Locate overload or change module.
7	-18v	8mv at 200ma load	Check voltage at the output of the rectifiers. This should be -27v with about 2v (peak-to-peak) ripple. Remedy: Locate overload or change module.
6	+45-50v	Negligible at 6ma load	Adjust to voltage shown on lid unless necessary to misadjust for dial calibration. Replace module if necessary.

Other Modules

Module	Connect detector to	Control setting	Detected output voltage, frequency, or waveform	Input
1	Disconnect Cable 3 from Module 5 and connect to detector.	Control A fully clockwise	Over 1v	+18v at 11ma
8A	Disconnect Cable 4 from module 5 and connect to detector.	SWEEP dial throughout range; front-panel LEVEL control fully clockwise	Over 0.5v square wave amplitude	Yellow: Positive voltage from Module 6. Sweep drive: Voltage from Module 6 or peaked waveform, depending on setting of SWEEP WIDTH control. Collector supply: Square wave, 18v amplitude.
	Disconnect Cable 1 from Module 2 and connect to detector.	SWEEP dial throughout range; front-panel LEVEL control fully clockwise	Over 40mv square wave amplitude	
	Connect Cable 1 from Module 8A to counter.	SWEEP dial throughout range; front-panel LEVEL control fully clockwise	50-62Mc; 50Mc should correspond to SWEEP dial setting of 0Mc and 62Mc to setting of 12Mc.	
8B	Disconnect Cable 2 from Module 2 and connect to detector.	MARKER dial throughout range	At least 50mv	+18v at 13ma
	Connect Cable 2 from Module 8B to counter.	MARKER dial throughout range	150-186Mc; 150Mc corresponds to dial setting of 0Mc and 186Mc to setting of 12Mc.	
5	Disconnect Cable 6 from Module 4 and connect to detector.	SWEEP dial throughout range; front-panel LEVEL control fully clockwise; Controls A and J fully clockwise	At least 0.2v	SWEEP: Square wave, 18v amplitude; CW: 18v at 18ma
4	Disconnect Cable 5 from Module 4; disconnect Cable 2 at both ends and use it to connect Jack 5 on Module 4 to the detector	SWEEP dial throughout range; front-panel LEVEL control and Control H fully clockwise; Control 6 for d-c balance	At least 2v	+18v at 80ma -18v at 80ma
2	Connect vertical oscilloscope input to P601-17	SWEEP and MARKER dials to same frequency; SWEEP WIDTH vernier fully clockwise; Control B to mid-range	"Birdy" at least 0.2v peak-to-peak in amplitude	+18v at 3ma
3	Follow the adjustment procedure outlined in TROUBLE-SHOOTING. The SWEEP dial must be indexed correctly before adjustment of this module is attempted.			

6-1. GENERAL.

6-2. This section provides the electrical parts list and the numbering system for the VR-2M PLUG-IN SWEEP OSCILLATOR.

6-3. COMPONENT NUMBERING SYSTEM. Table 6-1 specifies the numbering sequence used for each module in the VR-2M.

TABLE 6-1

Numbering Sequence	
100-199	Module 1
200-299	Module 2
300-399	Module 3
400-499	Module 4
500-599	Module 5
600-699	Module 6
700-799	Module 7
800-899	Module 8
900-999	Main Circuit Board and Front Panel

6-4. ELECTRICAL PARTS LIST. Table 6-2 provides the electrical parts list for the VR-2M.

TABLE 6-2

Electrical Parts List		
CIRCUIT REFERENCE NO.	DESCRIPTION	TELONIC PART NO.
C101	CFM, 150pf	C-96
C102	CFD, 33pf, 1000V	C-10
C103	CFD, 50pf, 1000V	C-172
C104	CFCF, 1000pf, 500V	C-126
C105	CFCF, 1000pf, 500V	C-118
C106	Same as C104	
C107	Same as C104	
C108	CFD, 7pf, 1000V (SC)	C-5
C109	Same as C104	

Table 6-2 (Cont.)

CIRCUIT REFERENCE NO.	DESCRIPTION	TELONIC PART NO.
C201	CFCF, 1000pf, 500V	C-126
C202	Same as C201	
C203	CFD, 0.1µf, 1000V	C-142
C204	Same as C201	
C205	CFMY, 0.33µf, 100V	C-141
C206	CFCF, 1000pf, 500V	C-118
C207	CFCF, 470pf, ±20%, 500VDCW	C-111
C301	CFD, 0.02µf, 500V	C-21
C302	CFCF, 1000pf, 500V	C-126
C303	Same as C302	
C401	CFE, 10µf, 25V	C-335
C402	Same as C401	
C403	CFD, 0.01µf, 150V	C-143
C404	Same as C401	
C405	CFCF, 1000pf, 500V	C-118
C406	Same as C405	
C501	CFM, 270pf	C-25
C502	CFM, 56pf	C-139
C503	Same as C501	
C504	CFM, 470pf	C-26
C505	Same as C504	
C506	Same as C504	
C507	CFM, 390pf	C-144
C508	CFD, 33pf, 1000V	C-10
C509	CFCF, 120pf, 500V	C-140
C510	Same as C509	
C511	Same as C509	
C512	CFCF, 120pf, 500V	C-124
C513	Same as C509	
C514	Same as C509	
C515	Same as C501	
C601	CFE, 30µf, 150VDC	C-306
C602	CFD, 0.001µf, 1000V	C-19
C701	CFE, 10µf, 25V	C-335
C801	CFM, 200pf, ±5%, 500VDCW	C-137
C802	CFN, 1pf, ±10%, 500VDCW	C-32
C803	CFM, 120pf, ±5%, 500VDCW	C-138
C804	CFCF, 120pf, 500V	C-140
C805	CFCF, 120pf, ±10%, 500VDCW	C-124
C806	Same as C804	
C807	Same as C805	
C808	CFM, 56pf	C-139
C809	Same as C805	

Table 6-2 (Cont)

CIRCUIT REFERENCE NO.	DESCRIPTION	TELONIC PART NO.
C810	Same as C 804	
C811	CFCF, 470pf, ±20%, 500VDCW	C-111
C812	Same as C804	
C813	Same as C805	
C851	CFN, 4pf, ±10%, 500VDCW (SC)	C-35
C852	Same as C851	
C853	CFCF, 1000pf, 500V	C-126
C854	CFCF, 1000pf, +100-0%, 500VDCW	C-110
C855	Same as C853	
C856	Same as C853	
C857	Same as C853	
C901	CFE, 30µf, 250VDCW	C-311
C902	CFD, 200pf	C-16
C903	CFE, 500µf, 50VDCW	C-334
C904	Same as C903	
C905	Same as C901	
C906	Same as C903	
C907	Same as C903	
CR201	DS, 1N82	D-17
CR202	Same as CR201	
CR301	DS, Zener, 1N977B, 45V	D-26
CR302	Same as CR301	
CR401	DS, Zener,UZ730, 30V	D-32
CR501	DS, 1N82	D-17
CR502	Same as CR501	
CR503	Same as CR501	
CR504	Same as CR501	
CR601	DS, Zener ZA68A	D-14
CR602	DS, TEL 101	D-24
CR603	Same as CR602	
CR701	DS, Zener, ZA18A	D-28
CR702	DS, TEL 101	D-24
CR801	DS, (Varactor) V4091	D-23
CR901	DS, Zener, ZA18A	D-28
CR902	DS, 1N2094	D-7
CR903	Same as CR902	
CR904	DS, FW-100	D-27
J101	Connector 27-9	J-91

Table 6-2 (Cont)

CIRCUIT REFERENCE NO.	DESCRIPTION	TELONIC PART NO.
J201	Connector 27-9	J-91
J202	Same as J201	
J401	Connector 27-9	J-91
J402	Same as J401	
J501	Connector 27-9	J-91
J502	Same as J501	
J503	Same as J501	
J801	Connector 27-9	J-91
J802	Same as J801	
J851	Same as J801	
L101	IF, 2.2μH, ±20%	L-100
L102	Same as L101	
L201	IF, 2.2μH, ±20%	L-100
L203	Same as L201	
L501	IV	N/A
L502	IV	N/A
L503	IV	N/A
L504	IV	N/A
L505	IV	N/A
L506	IF, 2.2μH, ±20%	L-100
L801	IV	N/A
L802	IF	N/A
L803	IV	N/A
L804	IV	N/A
L805	IF, 4.7μH, ±10%	L-120
L806	IF, 2.2μH, ±20%	L-100
L807	Same as L806	
L808	Same as L806	
L851	IF, 1μH, ±20%	L-119
L852	IV	N/A
L853	Same as L851	
L854	IF, 2.2μH, ±20%	L-100
L855	IV	N/A
L856	Same as L854	
P601	Barrier Plug	S-39
P901	Connector	J-74
Q101	Transistor, 2N706A	Q-11
Q102	Same as Q101	

Table 6-2 (Cont)

CIRCUIT REFERENCE NO.	DESCRIPTION	TELONIC PART NO.
Q201	Transistor, 2N1304	Q-3
Q401	Transistor, 2N2218	Q-10
Q402	Transistor, 2N697	Q-6
Q403	Transistor, 2N706A	Q-11
Q404	Transistor, 2N2904	Q-14
Q405	Same as Q402	
Q501	Transistor, 2N706A	Q-11
Q502	Same as Q501	
Q601	Transistor, 2N697	Q-6
Q602	Same as Q601	
Q603	Transistor, 2N398	Q-7
Q604	Transistor, 2N2102	Q-8
Q701	Transistor, 2N1131	Q-9
Q702	Transistor, 2N696	Q-12
Q703	Same as Q701	
Q704	Transistor, 2N1702	Q-13
Q801	Transistor, 2N706A	Q-11
Q802	Same as Q801	
Q803	Same as Q801	
Q851	Same as Q801	
Q852	Same as Q801	
Q853	Same as Q801	
R101	RFC, 27KΩ, ±10%, 1/4W	R-1428
R102	RFC, 68Ω, ±10%, 1/4W	R-1437
R103	RFC, 2.2KΩ, ±10%, 1/4W	R-1426
R104	Same as R101	
R105	Same as R103	
R106	RVC, 500Ω	R-793
R201	RFC, 47Ω, ±10%, 1/4W	R-1429
R202	RVC, 500Ω	R-793
R203	RFC, 470KΩ, ±10%, 1/4W	R-1436
R205	RFC, 2.2KΩ, ±10%, 1/4W	R-1426
R206	Same as R201	
R301	RFC, 4.7MΩ, ±10%, 1/4W	R-1438
R302	RFV, 500KΩ	R-794
R303	RFC, 100kΩ, ±10%, 1/4W (SC)	R-1424
R304	RFC, 1.2MΩ, ±10%, 1/2W	R-127
R305	RFV, 2MΩ	R-796
R306	RFC, 330KΩ, ±10%, 1/4W	R-1439
R307	RFV, 50KΩ	R-795
R308	Same as R302	

Table 6-2 (Cont)

CIRCUIT REFERENCE NO.	DESCRIPTION	TELONIC PART NO.
R309	Same as R303	
R310	RFC, 470KΩ, ±10%, 1/4W	R-1440
R311	RFC, 150KΩ, ±10%, 1/2W	R-98
R312	RFC, 4.7KΩ, ±10%, 1/4W	R-1430
R313	RFC, 270KΩ, ±10%, 1/2W	R-62
R314	RFCF, 3.32MΩ, ±1%, 1/2W	R-871
R315	Same as R313	
R401	RFC, 470Ω, ±10%, 1/4W	R-1402
R402	RFC, 1.8KΩ, ±10%, 1/4W	R-1467
R403	RFC, 47Ω, ±5%, 1/2W	R-85
R404	RFC, 4.7KΩ, ±5%, 1/4W	R-1447
R405	RFC, 1KΩ, ±10%, 1/2W	R-18
R406	RFC, 56Ω, ±10%, 1/4W	R-1401
R407	RVC, 500Ω	R-793
R408	Same as R402	
R409	RFC, 1.5KΩ, ±10%, 1/2W	R-139
R410	Same as R404 (SC)	
R411	Same as R407	
R412	Same as R406	
R413	RFC, 2.2KΩ, ±10%, 1/4W	R-1426
R414	Same as R403	
R501	RVC, 500Ω	R-793
R502	RFC, 22KΩ, ±10%, 1/4W	R-1417
R503	RFC, 1KΩ, ±10%, 1/4W	R-1427
R504	RFC, 2.2KΩ, ±10%, 1/4W	R-1426
R505	Same as R502	
R506	RFC, 4.7KΩ, ±10%, 1/4W	R-1430
R601	RFC, 12KΩ, ±5%, 1/4W	R-1433
R602	RFC, 4.7KΩ, ±10%, 1/4W	R-1430
R603	Thermistor, 100KΩ	MP-263
R604	RVC, 100KΩ	R-711
R605	Same as R601	
R606	RFC, 75KΩ, ±5%, 1/4W	R-1409
R607	RFC, 220KΩ, ±10%, 1/2W	R-44
R608	RFC, 15KΩ, ±10%, 1/4W	R-1434
R609	RFC, 220KΩ, ±10%, 1/4W	R-1435
R610	RFC, 1KΩ, ±10%, 1/4W	R-1427
R611	RFC, 47Ω, ±10%, 1/4W	R-1429
R612	RFC, 1MΩ, ±10%, 1/2W	R-31
R701	RFC, 10KΩ, ±10%, 1/2W	R-23
R702	RFC, 1KΩ, ±5%, 1/4W	R-1418
R703	RFC, 4.7KΩ, ±10%, 1/2W (SC)	R-21
R704	RFC, 2.7KΩ, ±10%, 1/4W	R-1469
R705	Same as R702	
R706	RFC, 3.3KΩ, ±10%, 1/4W	R-1461

Table 6-2 (Cont)

CIRCUIT REFERENCE NO.	DESCRIPTION	TELONIC PART NO.
R801	RFC, 47KΩ, ±10%, 1/4W	R-1423
R802	RFC, 100KΩ, ±10%, 1/4W (SC)	R-1424
R803	RFC, 56KΩ, ±10%, 1/4W (SC)	R-1425
R804	Same as R801	
R805	RFC, 2.2KΩ, ±10%, 1/4W	R-1426
R806	RFC, 1KΩ, ±10%, 1/4W	R-1427
R807	RFC, 27KΩ, ±10%, 1/4W	R-1428
R851	RFC, 22KΩ, ±10%, 1/4W	R-1417
R852	Same as R806	
R853	Same as R805	
R854	Same as R801	
R901	RFC, 1KΩ, ±10%, 1W	R-208
R902	PO S901	
R903	PO S901	
R904	PO S901	
R905	PO S901	
R906	RFCF, 10KΩ, ±10%, 5W	R-404
R907	RFC, 47KΩ, ±10%, 1W	R-210
R908	RFCF, 2KΩ, ±10%, 10W	R-505
R909	RFCF, 4KΩ, ±10%, 5W	R-416
R910	RFCF, 20Ω, ±10%, 5W	R-421
R911	Same as R910	
R912	Not Assigned	
R913	RVC, 15KΩ	R-797
R914	RFCF, 15KΩ, ±10%, 5W	R-420
R915	Same as R914	
RV301	Varistor	MP-262
S901	Switch Assy.	SW-51
T101	Transformer, Variable	NA
T102	Transformer, Variable	NA
T201	Transformer	NA
T501	Transformer	NA
T502	Transformer	NA
T901	Transformer, Power	T-21
V301	Nuvistor, 7586	VT-26
V302	Same as V301	
V303	Same as V301	

ABBREVIATION CODE

CFCF	Capacitor, Fixed, Ceramic, Feed-thru
CFD	Capacitor, Fixed, Discap
CFE	Capacitor, Fixed, Electrolytic
CFM	Capacitor, Fixed, Mica
CFMY	Capacitor, Fixed, Mylar
CFN	Capacitor, Fixed, Composition
DS	Diode, Semiconductor
IF	Inductor, Fixed
IV	Inductor, Variable
PO	Part Of
RFC	Resistor, Fixed, Composition
RFCF	Resistor, Fixed Carbon Film
SC	Subject to Change

SECTION VII

SCHEMATIC DIAGRAMS

7-1. GENERAL.

7-2. This section provides a block schematic diagram to aid in performing maintenance on the VR-2M PLUG-IN SWEEP OSCILLATOR.

7-3. All resistors are 1/2 watt ±10% and are shown in ohms unless otherwise specified.

7-4. All capacitors are shown in picofarads (pf) unless otherwise specified.

7-5. All coils are shown in microhenries (μH) unless otherwise specified.

7-6. All starred values are subject to change.

7-7. The following schematics are included in this manual:

a.	Module No. 1, 50 MHz Xtal Source	Figure 7-1
b.	Module No. 2, Variable Marker Mixer	Figure 7-2
c.	Module No. 3, Sweep Drive	Figure 7-3
d.	Module No. 4, Video Amplifier	Figure 7-4
e.	Module No. 5, Mixer and Low Pass Filter	Figure 7-5
f.	Module No. 6, 40/55V Aczener	Figure 7-6
g.	Module No. 7, Aczener	Figure 7-7
h.	Module No. 8, Sweep Oscillator and Variable Marker	Figure 7-8
i.	Main Printed Circuit Board	Figure 7-9

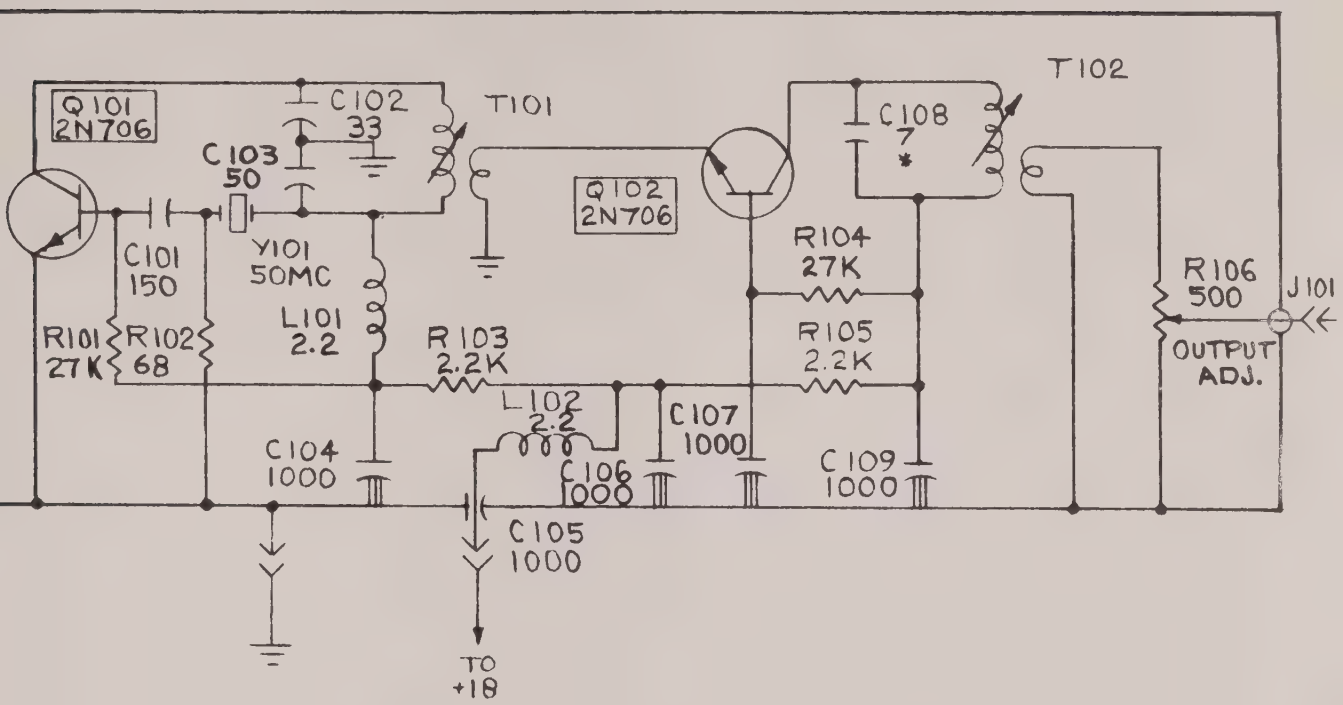


Figure 7-1 Module No. 1, 50 Mhz Xtal Source

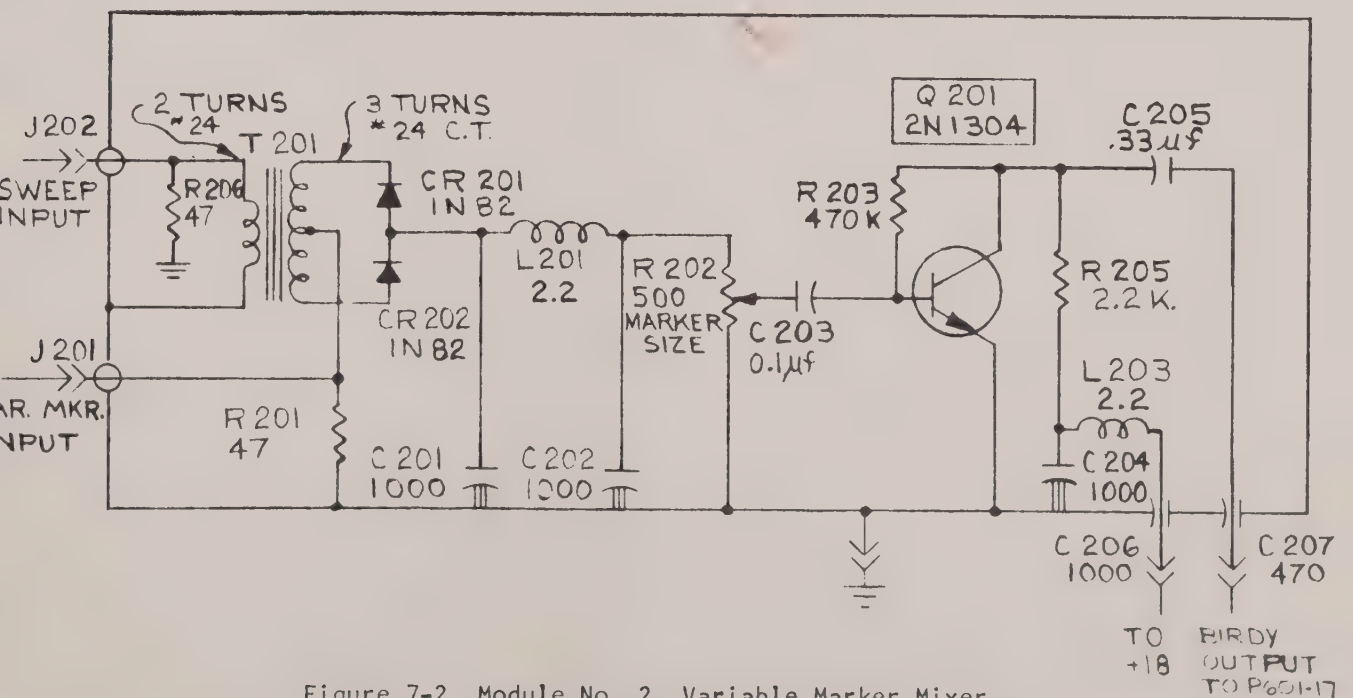
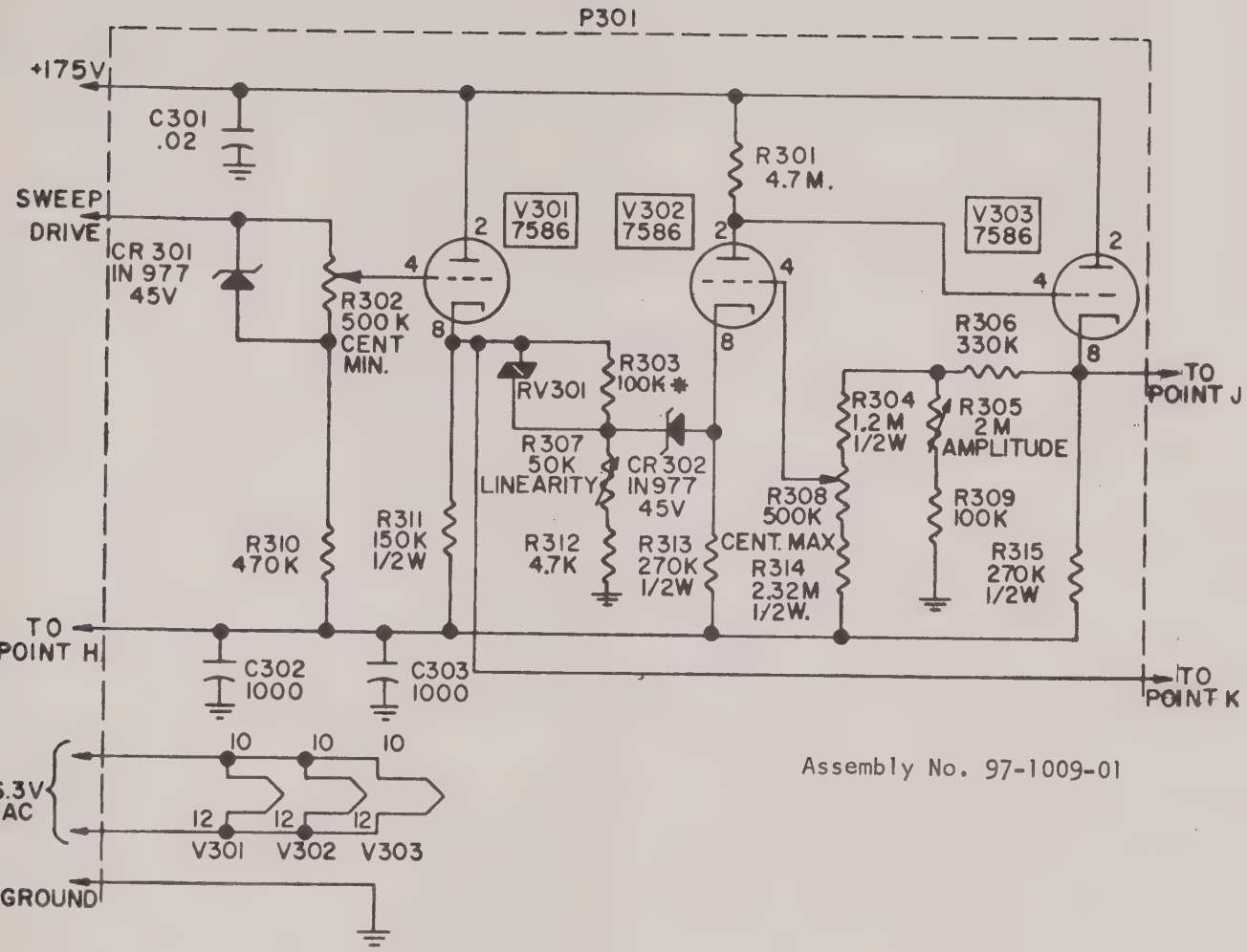


Figure 7-2 Module No. 2, Variable Marker Mixer



Assembly No. 97-1009-01

Figure 7-3 Sweep Drive Shaper

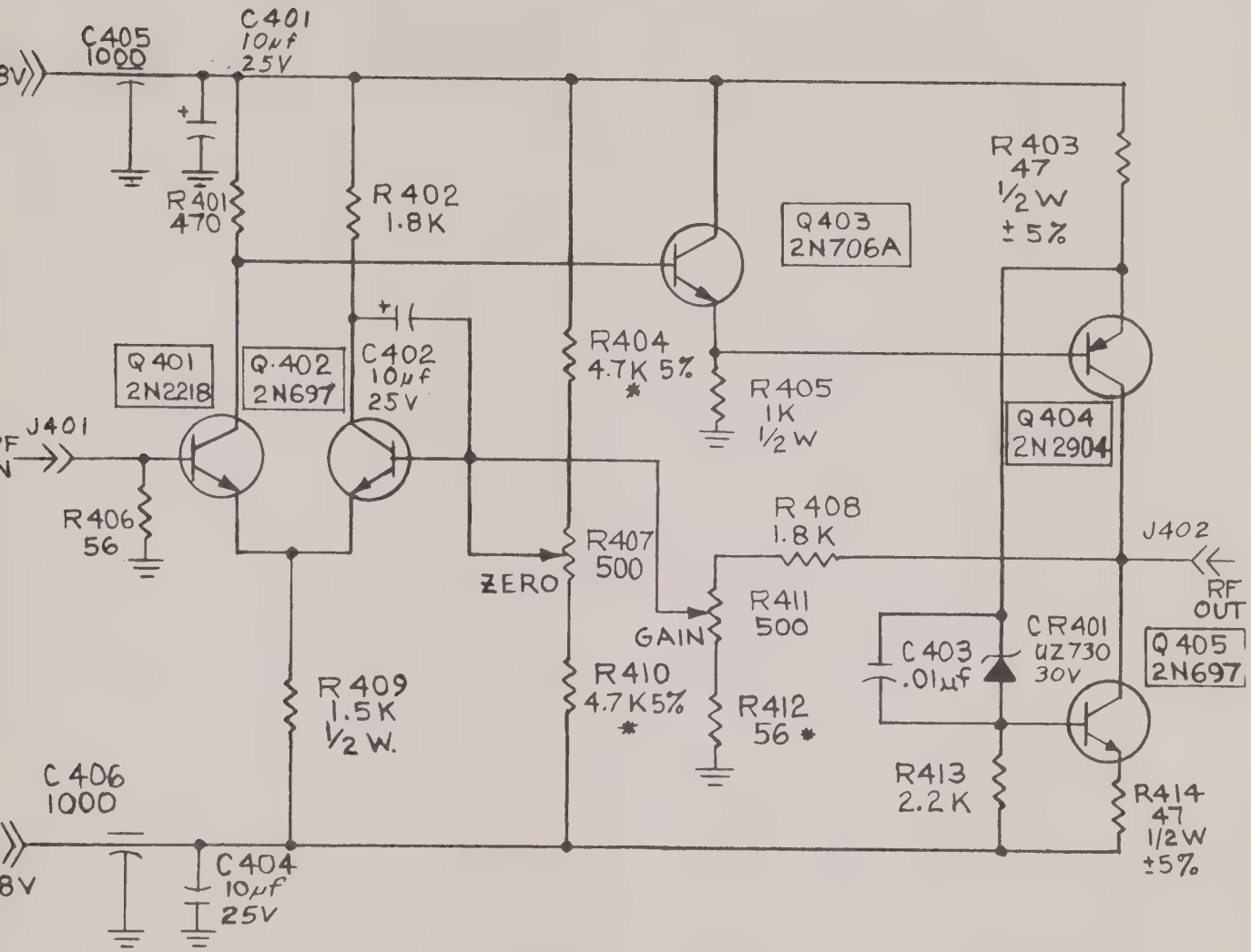


Figure 7-4 Module No. 4, Video Amplifer

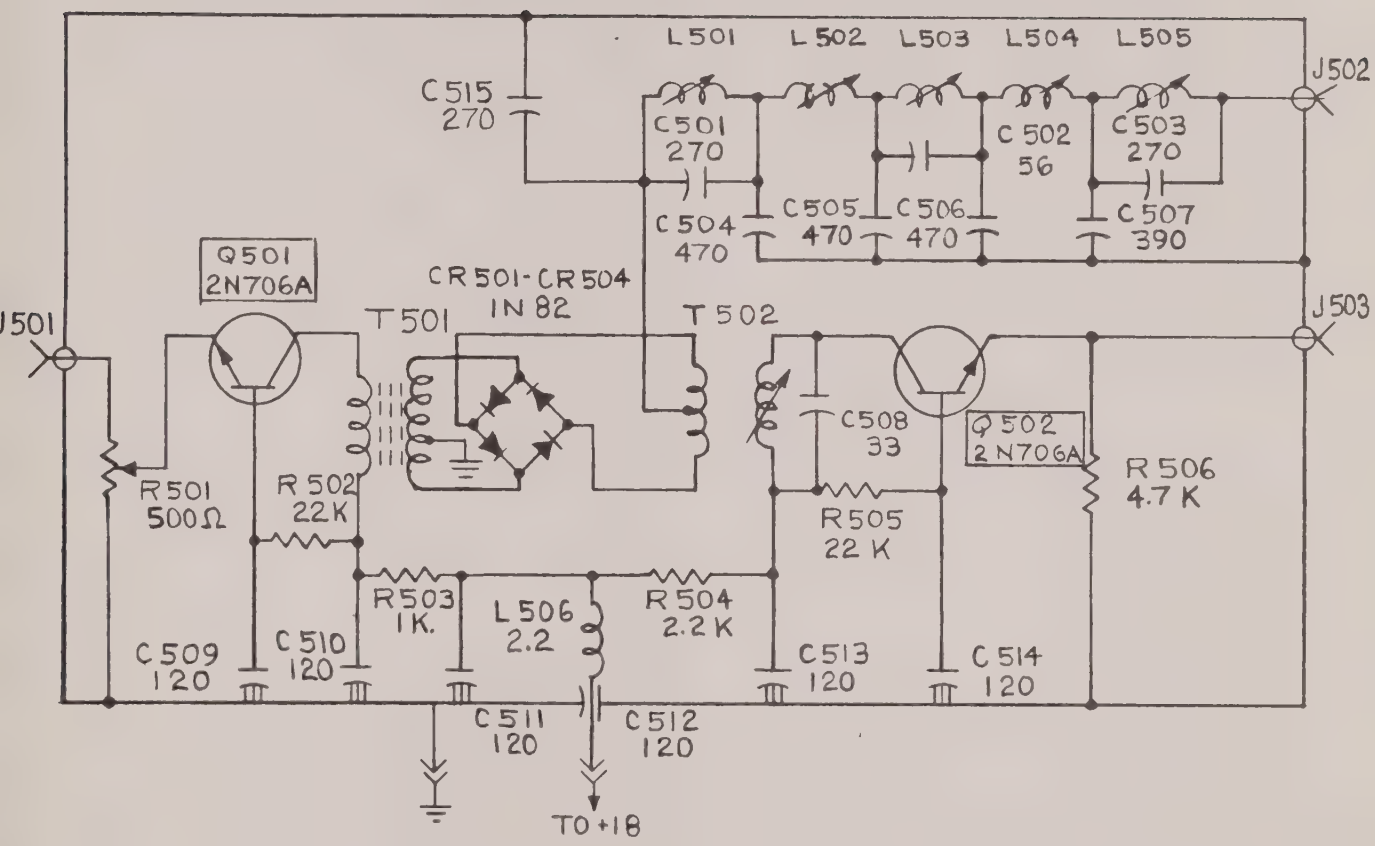


Figure 7-5 Module No. 5, Mixer & Low Pass Filter

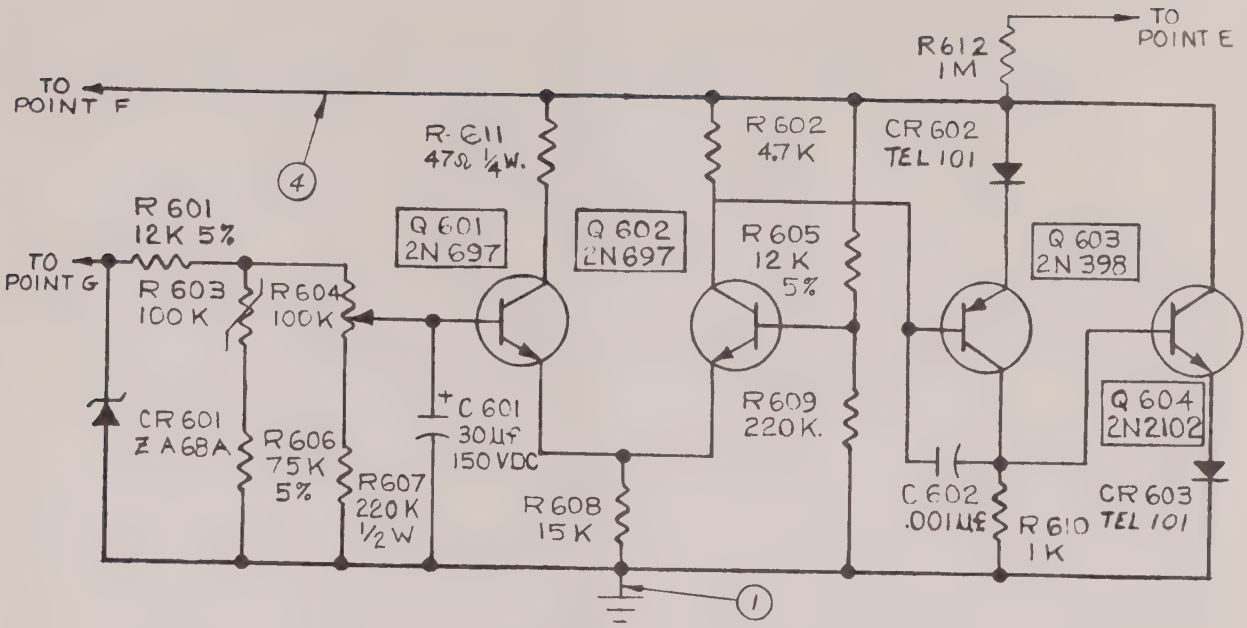


Figure 7-6 40 to 55 Volt Aczener

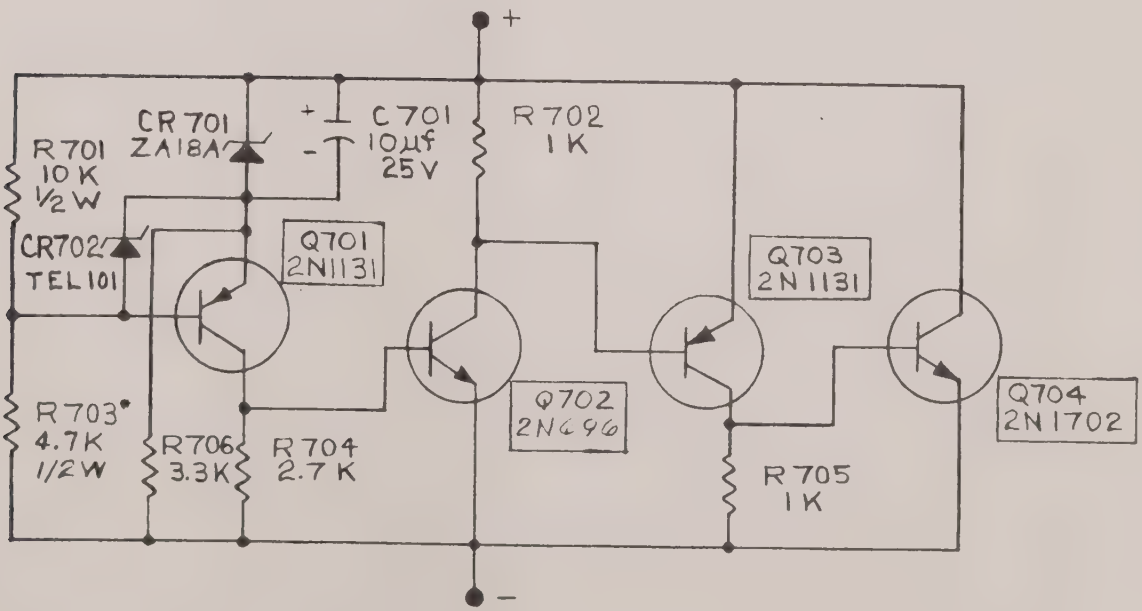
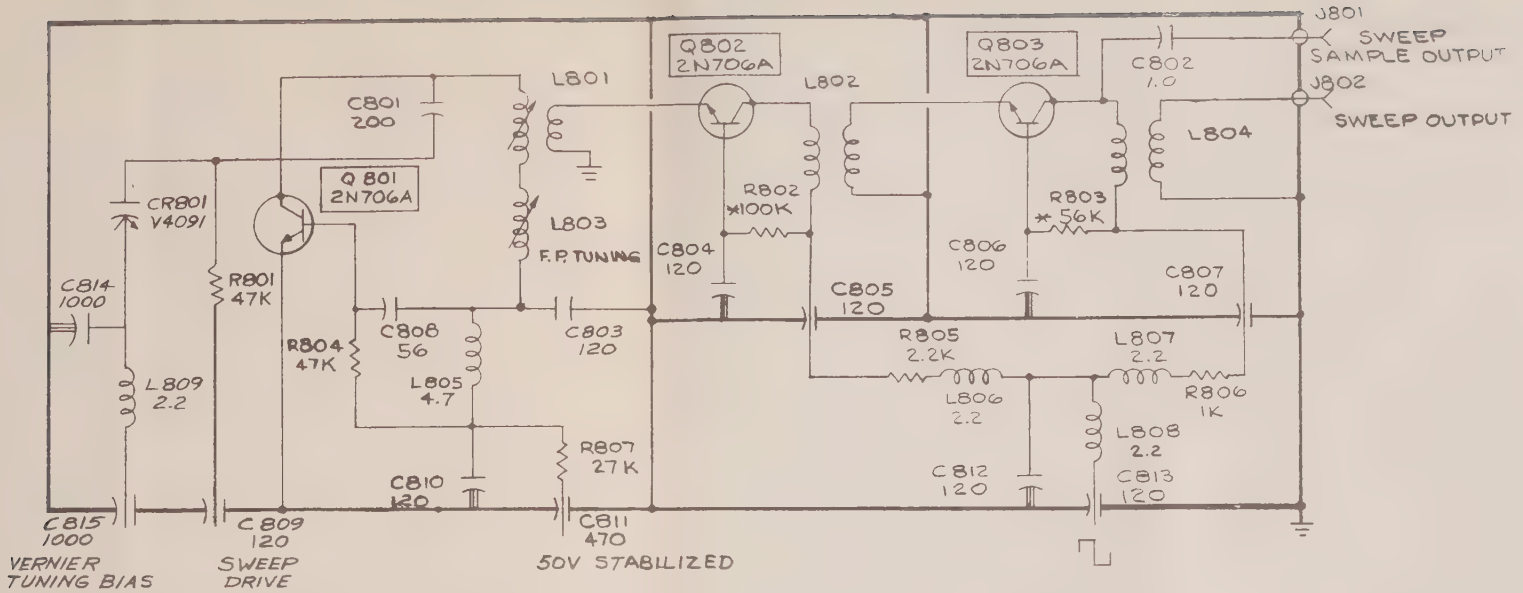
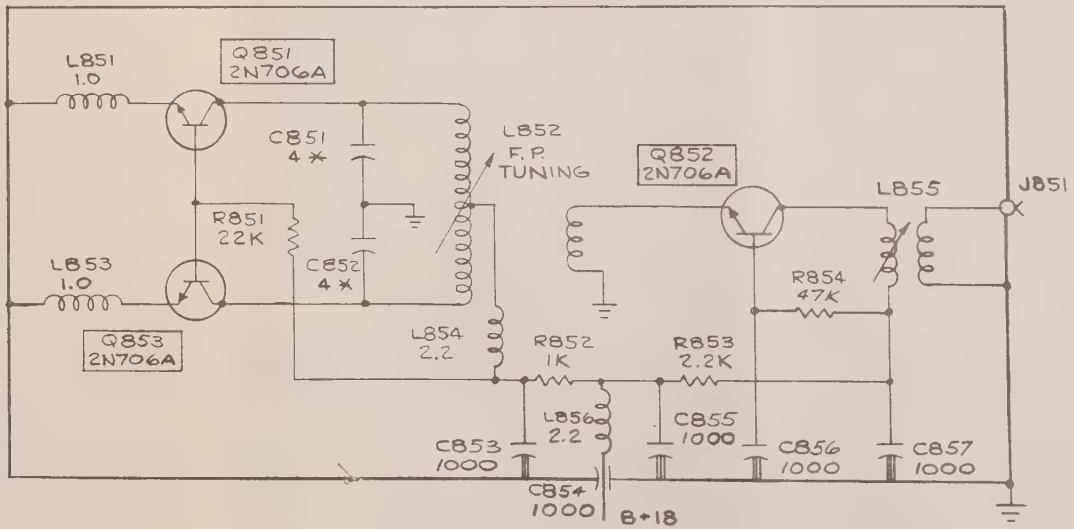


Figure 7-7 Module No. 7, Aczener



SWEEP OSCILLATOR



VARIABLE MARKER

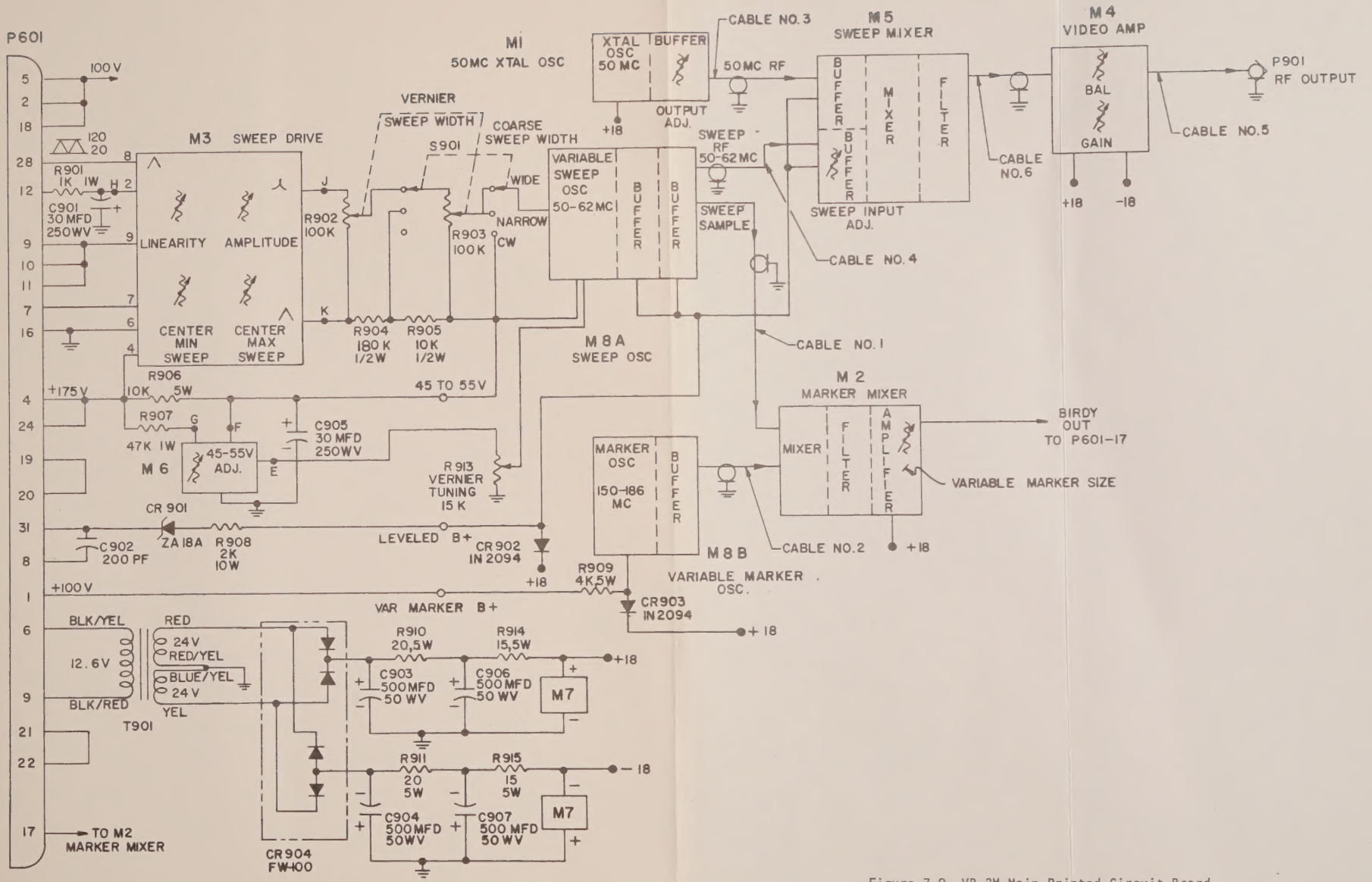


Figure 7-9 VR-2M Main Printed Circuit Board

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